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PUERTO RICO AGRICULTURAL EXPERIMENT STATION
MAYAGUEZ, PUERTO RICO

Under the supervision of the
UNITED STATES DEPARTMENT OF AGRICULTURE

REPORT OF THE PUERTO RICO
AGRICULTURAL EXPERIMENT
STATION

1934

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Issued January 1935



UNITED STATES DEPARTMENT OF AGRICULTURE
OFFICE OF EXPERIMENT STATIONS

PUERTO RICO AGRICULTURAL EXPERIMENT STATION, MAYAGUEZ

{Under the supervision of the Office of Experiment Stations, United States Department of Agriculture]

JAMES T. JARDINE, *Chief, Office of Experiment Stations*

STATION STAFF

T. B. McCLELLAND,¹ *Director*

H. L. VAN VOLKENBERG, *Parasitologist*

R. L. DAVIS, *Agronomist*

J. O. CARRERO, *Assistant Chemist*

A. ARROYO, *Minor Scientific Helper*

J. BRUNET, *Minor Scientific Helper*

C. ALEMAR, Jr., *Principal Clerk*

A. DIAZ, *Assistant Field Aid*

¹ Succeeded by Atherton Lee, July 2, 1934.

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MAYAGUEZ, PUERTO RICO

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Washington, D. C.

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INTRODUCTION

The work of the station during the year ended June 30, 1934, followed closely the lines of the preceding year, these having been selected for their major importance to the island. Sugarcane seedlings were extensively tested and widely distributed where their culture promised improvement over growing the established varieties. The propagation of at least one of the new seedling varieties has been almost as rapid as it was physically possible for a new variety to become established and extended. Other varieties not yet so extensively tested give early promise of being equally valuable. Special attention was given to working out improved methods of cane-sirup manufacture, a potentially important industry for the future of a cane-producing region which must reduce its sugar exportation. Coffee fertilization, varietal testing, shading, and spacing were all included in work in progress. Root crops, important locally as food,

were tested in fertilizer and strain-selection trials. Important studies of the parasites of livestock were continued.

Publications issued during the year were the Report of the Puerto Rico Agricultural Experiment Station for 1933; Bulletin 35, Sugarcane Variety P. O. J. 2878 in Puerto Rico, by R. L. Davis; Agricultural Notes Nos. 65, Variety Trials of Mayaguez Sugarcane Seedlings in 1933—Mayaguez 28 Shows Wide Adaptability, by R. L. Davis; 66, The Violet Tree, by N. L. Britton; and Maize Crossing Values in Second-Generation Lines, by R. L. Davis (Jour. Agr. Res. 48: 339-357. 1934).

SUGARCANE

EXTENSION OF MAYAGUEZ VARIETIES AND TESTS OF THEIR SUITABILITY TO PUERTO RICO

The Mayaguez sugarcane varieties were extended rapidly during the year by cane growers and sugar centrals until the area occupied was about 5 percent of the area under cane cultivation. The approximate acreage occupied in May 1934 was 11,000 acres, having more than doubled during the year. Most of this increase was owing to the extension of Mayaguez 28 which then occupied about 10,000 acres. The distribution of Mayaguez 28 acreage is shown in figure 1.

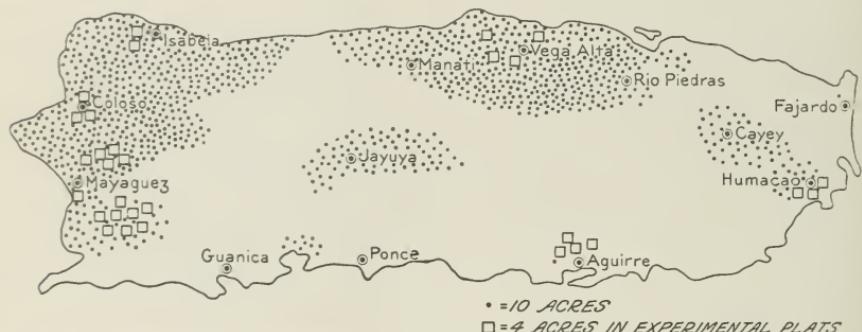


FIGURE 1.—Area occupied by Mayaguez 28. This variety occupied 10,000 acres in May 1934 and ranked first in area under cultivation at Coloso, Isabela, Jayuya, and San Sebastian.

Each cross represents 10 acres planted with Mayaguez 28. The extension of this variety has been particularly rapid along the north coast where it now occupies 3,000 acres, an increase of over four times since last reported.

Cuttings of the mosaic-resistant varieties Mayaguez 28 and 63 were sent out in small lots to 95 farmers. Also approximately 30 tons of cuttings were distributed to the Insular Experiment Station and various centrals for agronomic tests. The amount distributed for this purpose was less than in the preceding year, as the station has favored the policy of sending out only one-fourth ton lots and encouraging the sugar centrals to produce their own planting material for variety trials.

Tests of the adaptability of Mayaguez varieties to diverse climatic and soil conditions were continued in various parts of the island. Trials in cooperation with the Insular Experiment Station were made at the Quinones farm near San German and at the Mayaguez

station. Twenty-seven trials in cooperation with sugar centrals are located at Centrals Aguirre, Carmen, Coloso, Pagan, San Vicente, Roig, Yabucoa, and in the San German Valley district of Russell & Co. The circles in figure 1 show the distribution of these trials. The many trials located in the east and along the north coast, nearly doubling in number those of the past year, indicate an increased interest on the part of farmers and centrals in those districts in varieties produced at the station.

MAYAGUEZ 28

The acreage of Mayaguez 28 more than doubled in the year and ranked first in area under cultivation in four localities—at Coloso, 3,500 acres; at Isabela, 1,000 acres; at San Sebastian, 600 acres; and at Jayuya, 750 acres. Worthy of note is the spread along the north coast, where it is rapidly replacing S. C. 12/4 and P. O. J. 2725 in uplands, and to some extent B. H. 10 (12) in lowlands.

Mosaic resistance, drought resistance, high sucrose content, and ability to close in rapidly have combined to make the adoption of Mayaguez 28 very attractive, particularly in areas where the mosaic disease is a limiting factor. Its spread on the south coast, where mosaic is easily controlled, has been very slow. The desirable qualities of Mayaguez 28—resistance to mosaic, superior sucrose content, and comparative freedom from pith in arrowed stalks—were investigated. A study was also made of the arrowing habit of Mayaguez 28 in various parts of the island.

Resistance to mosaic.—The 1934 survey of fields of Mayaguez 28 confirms previous reports in respect to resistance to the mosaic disease. Over an 8-year period, this variety has resisted the disease although grown in fields adjoining infected cane. The most recent survey included Isabela, San Sebastian, and along the north coast, areas where during recent years the spread of mosaic infection in the susceptible varieties B. H. 10 (12) and S. C. 12/4 has been rapid. Mayaguez 28 is apparently commercially resistant to mosaic in other parts of the island as well as near Mayaguez and Coloso.

Early ripening.—Approximately 50,000 tons of Mayaguez 28 were ground during the 1934 crop season, principally at Isabela and Coloso. All available records of Central Coloso were examined and comparisons were made between analyses of Mayaguez 28 and of other varieties ground during the same 36-hour period and from fields comparable as to age and location. The juices of Mayaguez 28 *gran cultura*¹ cut in December and early January were rich and were almost invariably superior to those of P. O. J. 2878, P. O. J. 2725, and F. C. 916. The results from January grindings of Mayaguez 28 from the holdings of Central Coloso at Isabela were particularly noteworthy, 4 fields, totaling 20 acres, showing an average of over 12 percent of sugar in the cane. Equally favorable results were reported by Centrals Carmen and San Vicente and the Jayuya Development Co. At Jayuya, where Mayaguez 28 constituted the major portion of the crop, the juices clarified readily, and there was

¹ *Gran-cultura* plantings are made during the summer or fall and harvested when about 14 to 18 months old. *Primavera* plantings are made during the late winter or spring and harvested when about 12 months old.

no trouble with defecation such as has been experienced elsewhere with P. O. J. 2878. These results are in harmony with those of the 1933 season and indicate that Mayaguez 28 may be used to advantage for early grinding even in areas where it may be somewhat inferior to the standard variety in cane production.

Late cutting of gran-cultura plantings.—Canes of Mayaguez 28 are recumbent to reclining and develop a considerable amount of rot in late-harvested gran cultura. This was observed at the Isabela sub-station and at Humacao and confirms data from the preceding year.

In gran cultura at Yabucoa.—In the gran-cultura trial at Central Roig, Yabucoa, on humid lowland, Mayaguez 28 gave about the same cane production as B. H. 10 (12) and P. O. J. 2878. Its sucrose content was, however, inferior to that of the other varieties, indicating that gran cultura of Mayaguez 28 cut in February is not satisfactory on humid lowlands in the Yabucoa Valley. Additional trials are needed to confirm these results. Grindings of gran-cultura Mayaguez 28 made late in February at Isabela also resulted in juices inferior to those of P. O. J. 2878 and indicate that gran cultura of the former is not well suited for late grinding.

Rotten cane from heavy rainfall.—In first ratoons at Castro farm in the San German Valley on clay lowland without irrigation, Mayaguez 28 was inferior to P. O. J. 2878 by more than a ton of sugar per acre. This inferiority was due largely to the relatively high proportion of rotten cane that Mayaguez 28 developed as a result of abnormally heavy rainfall.

Primavera plantings.—In the primavera trial on irrigated clay at Limon farm near Central Coloso, Mayaguez 28 produced 4.1 tons of sugar per acre. That production exceeded B. H. 10 (12), approximately equaled P. O. J. 2878 and F. C. 916, but failed to equal Mayaguez 63 by about a ton of sugar per acre. Because of higher cultivation costs for Mayaguez 63 than for Mayaguez 28, the margin of superiority in profit per acre was less than would appear from comparisons of sugar production. At Central Carmen, San Antonio farm, on a shallow clay loam soil, Mayaguez 28 failed by a ton of sugar per acre to equal Mayaguez 63.

Mayaguez 28 was superior to other varieties in sucrose content in primavera trials harvested in April in both the Coloso and Carmen trials, where, although the sugar production of all three varieties was about the same, it was in each instance necessary to cut, haul, and grind several tons more of P. O. J. 2878 and of F. C. 916 than of Mayaguez 28.

In the primavera trial on unirrigated silt loam on the Ronda farm in the San German Valley, Mayaguez 28 produced 7.205 tons of sugar per acre, approximately 0.6 ton more than P. O. J. 2878. Its superiority was due largely to its richer juice. The contrast in purity was especially marked, 85.53 percent for Mayaguez 28 and 79.49 percent for P. O. J. 2878. These data substantiate those previously reported which indicated that Mayaguez 28 gave better results than P. O. J. 2878 on soil of this type. Condensed reports on the sucrose content of Mayaguez 28 were sent to centrals and planters interested in its culture.

Arrowing.—A survey of arrowing was made on 50 fields of Mayaguez 28. In each case the percentage of arrowing per 1,000 canes

was determined and the average height was estimated. The tops of Mayaguez 28 arrowed canes were more solid than those of P. O. J. 2725 in all fields examined. In some localities, where the average length of pithy cane of Mayaguez 28 was approximately 1 inch, that of P. O. J. 2725 was nearly a foot. The contrast was less marked between P. O. J. 2878 and Mayaguez 28. Pithiness in Mayaguez 28 arrowed canes was as a rule much more pronounced on dry upland slopes than in humid lowlands.

Unlike P. O. J. 2725, which arrowed profusely almost regardless of location, the arrowing of Mayaguez 28 varies according to local differences in climate, elevation, soil fertility, and time of planting. On San German Valley lowlands, where there is normally a protracted drought in winter, P. O. J. 2725 arrowed profusely regardless of the time of planting, whereas arrowing of Mayaguez 28 was negligible in both primavera and gran-cultura plantings. In fields of primavera planted in January on a fertile upland slope at an elevation of about 1,500 feet, near San Sebastian, the arrowing of P. O. J. 2725 was more than 75 percent, whereas that of Mayaguez 28 was less than 5 percent. Arrowing was negligible in primavera plantings on fertile level uplands and fertile lowlands of the north coast. The stunting effect of arrowing near Coloso, Aguadilla, and Aguada was less in primavera planted before March 1 than in later plantings. In general, the months of March and April should be avoided in planting primavera of Mayaguez 28; this does not apply to fertile humid lowlands of the north coast nor to the San German Valley where arrowing is not a limiting factor with this variety. Recommendations as to the probably more suitable planting periods for Mayaguez 28 primavera were made to the planters primarily interested.

A date-of-planting trial for Mayaguez 28 primavera was started on irrigated lowland at Central San Vicente. Six $\frac{1}{10}$ -acre plats of Mayaguez 28 alternating with a like number of B. H. 10 (12) plats were planted during each of the months of February, March, and April.

MAYAGUEZ 63, A PROMISING VARIETY

According to the results of this year's primavera trials, Mayaguez 63 is superior to Mayaguez 28, P. O. J. 2878, and F. C. 916 in primavera plantings by a wide margin. Its sucrose content in April was superior to that of P. O. J. 2878 and F. C. 916 at both Coloso and Carmen and only slightly inferior to that of Mayaguez 28. It should be borne in mind, however, that these results were secured from cane harvested rather late in the grinding season and do not at all indicate any superiority over Mayaguez 28 during the first months of harvest. Gran-cultura trials are now under way at Hormigueros, Humacao, Isabela, Mayaguez, and Yabucoa to compare the early ripening qualities of these varieties. In the first-ratoons trial on soil varying from clay to silty clay at the Margarita farm in the San German Valley, Mayaguez 63 ranked first in sugar production. It gave 5.16 tons of sugar per acre, 0.31 ton more than P. O. J. 2725 and 0.44 ton more than P. O. J. 2878. The sucrose content of Mayaguez 63 was somewhat superior to that of P. O. J. 2725. Additional data from ratoons of other agronomic test plats are needed to confirm these results.

Mayaguez 63, on account of its less prolific stooling, is less suited to hillside cultivation than is Mayaguez 28. Erosion on upland slopes would be much more rapid with Mayaguez 63 so that in a long period of cropping it would probably prove inferior to Mayaguez 28. Little is known about the ratooning qualities of Mayaguez 63 or its value in gran-cultura plantings, and planters are cautioned against too hasty an extension.

THIRD- AND FOURTH-YEAR SEEDLINGS

The growth made in one-twentieth acre plats at Hormigueros and at Centrals Aguirre, Coloso, San Vicente, and Carmen indicates that several crosses between Mayaguez 28 and P. O. J. 2878 are worthy of extensive agronomic tests. This is also true of a number of hybrids between B. H. 10 (12) and P. O. J. 2725. Seedlings of the latter combination are less prolific and probably less suited to extensive cultivation than are those of Mayaguez 28 crossed by P. O. J. 2878.

CROSSES WITH INBRED SEEDLINGS OF KASSOER

Through the cooperation of Central Roig at Yabucoa, and of the Fajardo Sugar Co., Ba. 11569 was cross-pollinated during November 1933 with Mayaguez 501 and 512. Approximately 140,000 seedlings were germinated, of which 30,000 were set in the field. They stool profusely and their broad leaves indicate that canes of satisfactory girth will develop. They are similar to P. O. J. 2878 insofar as they contain approximately one-quarter part Kassoer inheritance. The male or staminate parents are crosses between S. C. 12/4 and U. S. 541, the latter an inbred seedling of Kassoer supplied to the station by the Bureau of Plant Industry, United States Department of Agriculture.

SUMMARY OF SEEDLING VARIETY TRIALS, 1934

Figure 2 shows graphically the results of variety trials of cane cut in 1934.

Results from Mayaguez 3 and 42 on the Margarita farm in the San German Valley continued to be unfavorable. Both gave about the same sugar production as P. O. J. 2878 in the Anasco Valley (fig. 2, A and B), but are not as adaptable as the latter to adverse soil conditions nor as cheap to cultivate and are not being extended.

Mayaguez 7 equaled the production of P. O. J. 2725 in first ratoons at the Quinones farm. However, both P. O. J. 2878 and P. O. J. 2725 are regarded with greater favor on account of their prolific stooling.

According to observations on a total of over 50,000 stools, 100 to 300 stools per variety in each locality, Mayaguez 28 closed in more rapidly than P. O. J. 2878 or P. O. J. 2725, and was the cheapest cane to cultivate. Mayaguez 28 in primavera tests equalled P. O. J. 2878 and F. C. 916 in sugar production at Centrals Coloso and Carmen (fig. 2, C and D) and exceeded P. O. J. 2878 by about one-half ton of sugar per acre on silt loam at Ronda farm (fig. 2, E) in the San German Valley. Mayaguez 28 developed much rotten cane in late-cut gran cultura at Yabucoa and Isabela, and in first ratoons at Castro (fig. 2, F). The planters are again cautioned against extend-

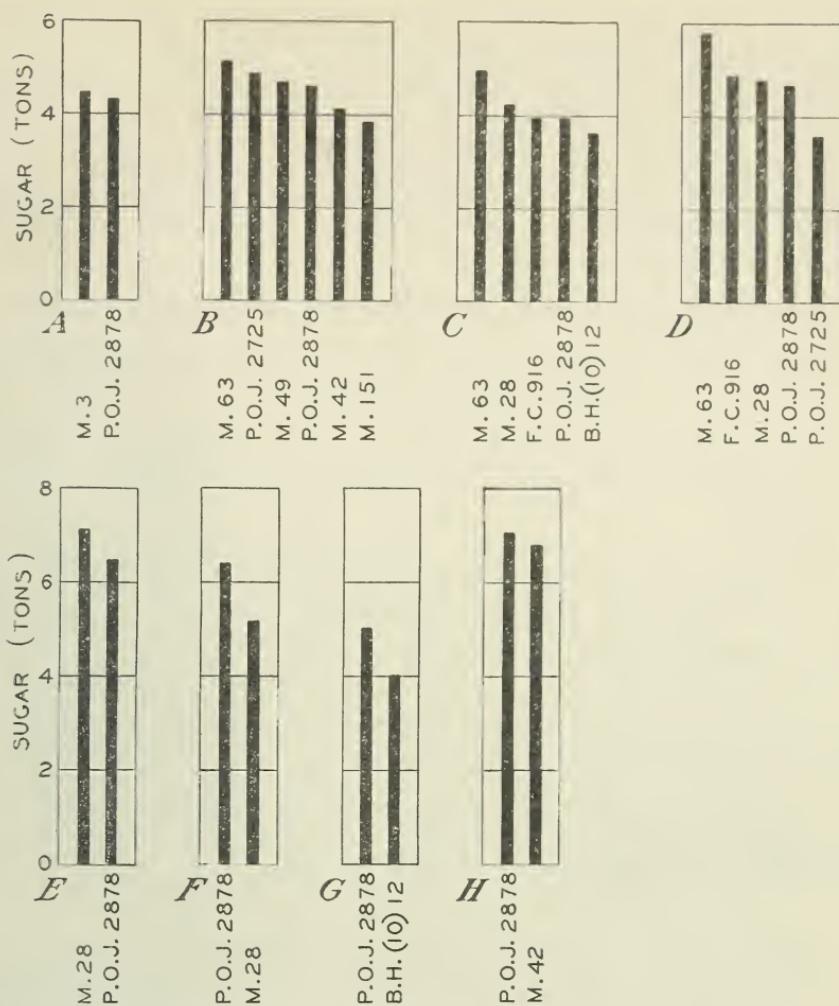


FIGURE 2.—*A*, Average yield of sugar from four $\frac{1}{8}$ -acre plats of each variety, Pagan primavera. Mayaguez 3 gave about the same production as P. O. J. 2878 but is considered inferior to the latter because it is less adaptable to varied soil conditions. *B*, Average yield of sugar from four $\frac{1}{40}$ -acre plats of each variety, Margarita first ratoons. Mayaguez 63 ratoons were somewhat superior to P. O. J. 2725 and P. O. J. 2878 in the San German Valley on unirrigated clay lowland. This trial and those at Ronda and Castro were conducted through the cooperation of Owen Proverbs, field superintendent, Russell & Co. *C*, Average yield of sugar from six $\frac{1}{15}$ -acre plats of each variety, Coloso primavera. Mayaguez 63 primavera outyielded all other varieties by about a ton of sugar per acre on irrigated clay lowland. Mayaguez 28 was superior to all other varieties in sucrose content. The superiority of Mayaguez 63 was owing in part to its having resisted the effect of a violent windstorm in the fall of 1933. *D*, Average yield of sugar from six $\frac{1}{15}$ -acre plats of each variety, Central Carmen primavera. Mayaguez 63 primavera on shallow clay loam semipland exceeded P. O. J. 2878, F. C. 916, and Mayaguez 28 by a ton of sugar per acre. Mayaguez 28 was superior to all other varieties in sucrose content. *E*, Average yield of sugar from five $\frac{1}{40}$ -acre plats of each variety, Pagan primavera. Mayaguez 28 primavera was superior to P. O. J. 2878 on silt loam in the San German Valley owing to both higher cane production and richer juices. *F*, Average yield of sugar from five $\frac{1}{40}$ -acre plats of each variety, Castro first ratoons. Owing largely to a high proportion of rotten cane Mayaguez 28 was inferior to P. O. J. 2878 by over a ton of sugar per acre in first ratoons on unirrigated clay lowland in the San German Valley. *G*, Average yield of sugar, second ratoons, from four $\frac{1}{8}$ -acre plats of each variety, at Dolores. P. O. J. 2878 ratoons exceeded B. H. 10 (12) by a ton of sugar per acre in the Anasco Valley. *H*, Average yield of sugar from ten $\frac{1}{40}$ -acre plats of each variety in irrigated gran cultura at Central Pagan in the Anasco Valley. Mayaguez 42 was nearly equal to P. O. J. 2878 in sugar production. The latter is preferred because of cheaper cultivation costs.

ing this variety in gran cultura on humid lowlands, particularly in areas of heavy rainfall such as the Yabueoa Valley.

Mayaguez 63 was outstanding for sugar production in primavera trials at Coloso and Carmen (fig. 2, C and D), where it exceeded all other varieties by about a ton of sugar per acre; in first ratoons in the San German Valley it was somewhat superior to both P. O. J. 2725 and P. O. J. 2878. The juices of Mayaguez 63 were very satisfactory during April and indicate that it ripens well late in the grinding season.

P. O. J. 2878 RANKS FIRST IN THE SAN GERMAN AND ANASCO VALLEYS

P. O. J. 2878 continues to give superior results in the San German Valley, where it occupies nearly nine-tenths of the area under cultivation. It has given very good juices there and with the exception of plantings on silt loam, where it proved inferior to Mayaguez 28 in primavera trials, and in the Margarita trial (fig. 2, B), where Mayaguez 63 ranked first, it has led all other varieties in sugar production.

In the Anasco Valley, P. O. J. 2878 is planted almost exclusively. In a second-ratoon variety trial at Dolores farm in this district (fig. 2, G) P. O. J. 2878 produced approximately a ton of sugar per acre more than B. H. 10 (12). In the primavera trial at Central Pagan, Anasco (fig. 2, A), P. O. J. 2878 gave the same sugar production per acre as Mayaguez 3, although it was somewhat inferior in cane production. In gran-cultura trial on semiupland slope at Librado farm of Central Pagan (fig. 2, H), P. O. J. 2878 was somewhat superior to Mayaguez 42. Assuming equal productions for these varieties, P. O. J. 2878 is, on account of its greater prolificness and superior resistance to drought, a better variety than either Mayaguez 3 or Mayaguez 42 for that district.

TRIP OF THE AGRONOMIST TO THE GULF STATES

In May 1934 the station agronomist made a trip to the Gulf States for the purpose of studying the methods used and results obtained in the breeding and testing of sugarcane varieties. The chief points of interest were the technic used in determining disease resistance and in agronomic tests, and the equipment requisite. The use of many replications of small plats is favored at the Houma, La., sugar plant field station of the Bureau of Plant Industry. A similar practice would be desirable in Puerto Rico, particularly in preliminary trials. The equipment for testing and weighing numerous small plats has been largely motorized. At the Everglades Experiment Station of the University of Florida a sugar mill mounted on an autotruck chassis and connected directly to the gears of an automobile engine is used in the field for extracting juice samples. This has made possible the analyzing of several thousand seedlings each season by a limited personnel. At Houma a weigh scale is mounted on a truck chassis and weights are taken in the field; the data secured in this way are more accurate than those usually obtainable from the large sugar-mill weigh scales.

From the viewpoint of the sugar planter, the chief interest was in the method of making preharvest analyses of the fields. In each

field two men working together remove cores, of approximately three-eighths-inch diameter, from the center of each of 200 canes. The cores are removed by a punch fastened on a chamber large enough to hold 100 cores. The juice is extracted from the cores by means of a fruit press and the percentage of total solids is determined in the field by means of a hand refractometer. The remainder of each juice sample is then treated with lead acetate and sent into the laboratory to be analyzed for sucrose. A close correlation has been observed between analyses made by this method and the crusher-juice analyses later secured from the respective fields. This method could be used to advantage in Puerto Rico, particularly early in the grinding season, when trouble is experienced in selecting fields which will give satisfactory juices.

CANE-SIRUP MANUFACTURE

The establishment of a sugar quota for the island with the attendant reduction in the amount of sugar that may be exported intensifies the search for other products. One such product is sirup. Good sirup, except such as may be found in an imported can, is very difficult or usually impossible to purchase locally. The manufacture of a good cane sirup offers commercial possibilities both for local consumption and for export trade. The fame of Puerto Rican molasses was once wide-spread. The product later ceased to be generally obtainable. On the basis of the old reputation, it should not be difficult to build for a new and better product a new and better market than the older product enjoyed. The investigations by the station of methods of manufacture which would produce a high-quality product have been intensified.

The earlier trials in the manufacture of sugarcane sirup were carried out with the juices available at the time. The quality of the final product varied according to both the method employed and the variety of cane used, since the juices vary according to the variety of cane, its age, sugar content and purity, the amount of coloring matter present, and the content of wax and gums. All of these affect the manufacture and the quality of the final product.

TESTS OF CANES GROWN UNDER ABNORMAL CONDITIONS

For further investigation a planting was made of a number of the varieties now grown in the island, namely, S. C. 12/4, P. O. J. 2725 and 2878, F. C. 916, P. R. 803, and Mayaguez 28, 42, and 47. All varieties were planted in the same kind of soil, and methods of planting and fertilization were the same for all. The development of all varieties was good until at 5½ months a heavy wind blew down all of the canes except Mayaguez 42 and S. C. 12/4. The overthrown canes continued growth, however, roots developing at the internodes. Later, rats attacked and severely damaged the canes.

These abnormal growth conditions made the results of the analyses less dependable and necessitated giving up altogether certain investigations which had been planned in connection with the mineral content of the juices.

Grinding started when canes were 6 months old. Seven grindings were made, the first to the fourth at 15-day intervals, and thereafter, at 30-day intervals.² Analysis was made for sucrose, reducing sugars, phosphoric acid, potash, and coloring matter.

Definite conclusions cannot be drawn owing to the abnormal conditions under which the canes developed. However, in these tests the varieties listed in sequence of early to late sucrose development were as follows: Mayaguez 42, F. C. 998, B. H. 10 (12), F. C. 916, P. O. J. 2878, M. 28, S. C. 12/4, P. O. J. 2725, P. R. 803, and M. 49.

COLOR VARIATION OF JUICE ACCORDING TO VARIETY

Juices filtered through cotton were placed in small cylinders for comparison. They varied in color from an olive through grayish to a pronounced dark green color. When placed in order of light to dark color the juices stood as follows: S. C. 12/4, P. R. 803, M. 42, P. O. J. 2725, M. 28, F. C. 916, M. 49, P. O. J. 2878, and F. C. 998, the latter two very dark. Colors were also compared after the juices were boiled for 3 minutes and then filtered by means of kieselguhr. The sequence was the same as for the unfiltered juices.

DEFECATION OR CLARIFICATION

Attention was first given to methods in use by sugar centrals, employing lime alone or lime and phosphoric acid. Filtration was slightly faster in the second than in the first case. An almost brilliant juice was obtained. The process was speeded up by use of fine or precipitated lime carbonate or kieselguhr. However, both methods had pronounced disadvantages—neutralization by lime alone caused considerable darkening of juices, but the original color could be restored on restoration of original acidity. Upon concentration of the juice, in both processes, the formation of a precipitate occurred, which made necessary a second decantation or filtration. The final product although of a fairly pleasant taste had lost a considerable amount of the pleasing flavor present in sirup from untreated juices.

Five additional methods were tried—that ordinarily used in factories, the use of aluminum hydrate, the use of extract of maguey or of cassia, the use of ferric salts, and filtration through filter-cel. In all cases prior to treatment the juices were heated up to boiling and the scums rising to the top were removed. The advantage in this was that smaller amounts of chemicals were needed and the filtration rate of the juice was higher. The ordinary factory method yielded the darkest product with a considerable amount of fine material in suspension. The use of aluminum hydrate showed little advantage over the preceding except when the amounts employed were such as to be considered prohibitive on account of cost. Extract of maguey leaves or of cassia, especially the latter, had remarkable clarifying properties, causing flocculation and precipitation of considerable material that ordinarily remains in suspension. However, the precipitate appeared light in weight and was hard to filter. Ferric

² Acknowledgment is made of aid given by F. G. Suria, manager of Central Eureka, and Ulpiano E. Colom, of the Insular Department of Agriculture, in obtaining material for subsequent work.

salts yielded the clearest juices. The precipitate, though voluminous, was heavy, and on addition of a small amount of kieselguhr, settled rapidly to a small volume. Heating to boiling and filtration through kieselguhr or filter-cel yielded an almost limpid brilliant juice but this contained a very small amount of the finest colloidal matter. Of the methods tried, filtration through filter-cel yielded the clearest product. The next clearest was obtained by treatment with ferric salts.

FILTRATION

A pronounced darkening of color is brought about by filtration of juices. Although the color lightens up slightly on heating and boiling the juice, the final product, which is almost clear, possesses a pronounced dark color. A still darker shade is obtained whenever the reaction of the juice is changed from slightly acid to neutral or slightly alkaline. On the other hand, when filtered juices are made slightly more acid the resultant color is lighter, varying from a golden yellow to a light brown. The amount of acid needed to effect a change in color is small, and only slightly affects the flavor. The acid used was tartaric, which is present in a large number of fruits and food products as ordinarily consumed.

BOILING

The care exercised in the boiling and concentration of the juice affects the color and quality even more than the factors already discussed. The longer the period for concentration, the darker the final product. Evaporation may be speeded up in the early stages but great care must be taken in the last stage, as high heat at that time may cause considerable caramelization with a resultant darkening in color.

Filtration speeds up evaporation considerably. In unfiltered juices there is a flocculation of material which tends to settle, the amount varying with the variety. Greater carbonization results, giving the syrup a darker color and a scorched flavor, both of which are undesirable.

FLAVOR AND COLOR OF SIRUP

Both flavor and color vary with the different varieties and the different methods of manufacture.

Juices that had been subjected only to filtration with filter-cel yielded sirups with the best flavor. Those from juices which had been fermented ranked second. When sirups from the different varieties were compared, those from the variety Mayaguez 42 ranked first, with those from F. C. 998 and B. H. 10 (12) as very close seconds.

Sirups from juices which had been fermented were lightest in color, a light brown, and were considered attractive in appearance. Those from juices that had been filtered only ranked close seconds. Decided reduction in color can be obtained by treatment with active carbons or by increasing the acidity of the juice. Treatment with active carbons reduces the color to one-third or less of that of syrup from untreated juices. However, its use is considered objectionable, since, although the syrup has improved in appearance it has deteriorated in flavor, and the cost of manufacture has increased.

Increasing the acidity of juices lightened the color. Tartaric or citric acids were used, the first being preferred. To secure a considerable reduction in color an excessive amount of acid had to be added. However, a fair reduction was obtained by the addition of an amount which was not noticeable to the taste.

A sirup both pleasing in flavor and attractive in appearance can be obtained by blending the products of two or three methods of manufacture.

CRYSTALLIZATION

Crystallization does not begin immediately upon concentration of the juice to the density suitable for sirup, but after standing for some days small sugar crystals appear. Their growth depends on sirup density, temperature, and length of standing. This crystallization is ordinarily prevented by partial inversion of the sugar by invertase.

A method was developed in which fermentation of the juice was induced by the addition of a pure yeast culture. Natural fermentation had the desired effect as far as inversion was concerned, and the final product could be brought to a higher density with no crystal formation. However, in a majority of the cases when natural fermentation of the juices was allowed, a peculiar fermentation took place producing a viscous, gummy product with a very high degree of acidity. Canes from different fields and different localities seem to carry the infection.

Development of the infection was avoided by the addition of a pure yeast culture. When this was allowed to act for 5 to 6 hours, the following advantages resulted: A considerable amount of the scum-forming material present in the juice coagulated, rising to the top where it could be skimmed prior to heating. On heating, a large amount of the coagulating matter rose to the top with bubbles and could be taken off easily; after filtering the juice, it could be evaporated to a higher degree of density than when not fermented; in most instances the color of the final product was lighter than that from unfermented juices. Disadvantages were that the sirup from fermented juices had lost some of the pleasant characteristic quality present in sirup from unfermented juices, and a slightly larger amount of filter-cel was required for proper filtration.

MOLDS AND DARKENING IN STORED SIRUP

The sirup, when stored hot in clean bottles, shows no deterioration when the bottles are kept properly stoppered, but molds are apt to grow when the containers are opened frequently. Molds develop more easily in the lighter than in the heavier sirups. When the containers are not tightly stoppered and fresh air comes in contact with the sirup, a gradual darkening starts at the surface and spreads slowly downward, giving the sirup a less attractive appearance.

COFFEE

SHADING

The experiment in which coffee plants artificially shaded are compared with other plants of the same clons grown under full sun exposure has now been in progress more than 2 years. In the first

small crop, picked in the current year, the plants receiving the lighter shade gave the largest production, but, when the production was considered by individual clons, the response was too irregular to warrant conclusions. Although the average trunk diameter at 2



FIGURE 3.—Coffee grown under half shade in lath house.

years was greater in both of the shaded groups than in the unshaded, the increase in trunk diameter within the year was greatest in the latter. The shaded plants (fig. 3) continue to be larger, more open, with larger leaves and longer internodes, and drooping branches, whereas the unshaded plants (fig. 4) are shorter, stockier, with

smaller leaves and shorter internodes, and with the branches of the upper portion of the tree pointing sharply upward.

The differences between the shaded and the unshaded plants are as pronounced as are varietal differences in plants grown under uniform conditions. It is interesting to note that in a region where all coffee is grown under shade, the unshaded plants appear very vigorous and are now carrying a heavy crop.

FERTILIZATION

The flood of March 1933 so damaged the major series of plats of coffee trees on which fertilizer work was in progress that they had to be abandoned. A much more comprehensive experiment was



FIGURE 4.—Coffee grown under full sun exposure. The plant at the right is of the same clon and age as that shown in figure 3.

accordingly planned and 223 plats were laid out, ditched, and planted with temporary shade trees and cover crops on an elevated plain not subject to flooding. A nursery of both coffee and shade trees was established from the earliest available seed, thus furnishing an ample supply of seedlings for setting in the present season. The results from this very comprehensive test, in which it is planned to vary each fertilizer element from 1 to 9 units in alternating series, should give decided indications as to suitable amounts and ratios of nitrogen, phosphoric acid, and potash in coffee-fertilizer mixtures on soil such as that of the test.

Experiments in progress for some years at the station and at Las Vegas have clearly demonstrated the pronounced response of the coffee tree to potash fertilization on soils such as those of this station and of the coffee region of Las Vegas, both typical as regards soil, of large coffee-growing areas. Nitrogen also is needed, but is less

important. Phosphoric acid in some tests has been entirely without value. Further trials are needed to show the most suitable ratios and the most profitable amounts to apply.

The determination of facts in relation to coffee fertilization in Puerto Rico is one of the most effective means by which the station can aid the coffee planter. If adequate production is to be obtained from coffee plantings on the long-cropped and exhausted soils of Puerto Rico, fertilization must be practiced. The need for it is indicated by the pronounced response in growth and crop following suitable fertilization.

SPACING

Coffee in Puerto Rico is usually closely planted. An acre of typical native coffee will contain 1,000 to 2,000 or more coffee plants. That a very much smaller number of well-cared-for plants may produce as much or more was demonstrated by a spacing test which has been in progress since 1930.

A block of 60 plants of the Bourbon variety (*Coffea arabica*) uniformly set 8 by 8 feet in 12 rows of 5 plants each was selected for the test. This planting had been fertilized for years and the plants were crowding one another even though spaced at the rate of only 680 plants to the acre, a number far below that of the average Puerto Rican planting. Rows 1 to 6 gave an average annual yield per plant of 3.8 liters of coffee cherries and rows 7 to 12 gave 4.7 liters, for the crops of 1929 and 1930. Immediately after the 1930 crop alternate plants were removed from rows 1 to 6, reducing a block of 30 plants spaced 8 by 8 feet to one of 15 plants spaced 11.3 by 11.3 feet, the altered rate being only 340 plants to the acre. Rows 7 to 12 were left untouched. There remained then two blocks occupying equal areas, but one containing twice as many plants as the other.

Three crops have followed. In each the yield per plant has been greater from the widely spaced plants. In the 2 earlier of the 3 crops the area yield of the more closely spaced plants was the greater, but in the aggregate of the 3 crops the 15 widely spaced plants outyielded as a unit the 30 more closely spaced, the area yield of the former surpassing that of the latter by 5 percent. Reduced to an annual average, the yield was 7.2 liters of coffee cherries per widely spaced plant and 3.4 liters per closely spaced plant. All have been well fertilized with equal amounts of complete fertilizer per plant. As the fertilizer application was based on the number of plants rather than on the area, twice as much fertilizer was required for the more closely spaced plants as for the more widely spaced, thus entailing much greater cost of production for the crop from the more closely set plants.

EXCELSA COFFEE

The potential value of Excelsa coffee in Puerto Rico has been demonstrated by results from a number of plantings at the station. It is a variety which is now meeting with favorable acceptance by numerous planters, and extensive seed distribution has been made by the station. Its vigor, resistance to leaf miner, and its productivity commend it for planting in localities where the Arabian coffee is less successful because of leaf miner or impoverished soil. The prin-

cipal difficulty encountered in its cultivation is the height to which the tree normally grows, and the consequent loss of much of the crop through inability to collect it if the tree has been left untopped.



FIGURE 5.—Excelsa coffee plant 2 years from seed, ready for topping at the point indicated by the finger tips.

A very satisfactory system of topping and pruning has been developed and tested at the station. It consists in topping the young tree soon after the development of the fourth pair of branches. A diagonal cut is made through the node at this point, removing the upright and one lateral branch of the fourth pair (figs. 5 and 6).

Uprights which develop thereafter are removed and further lateral growth develops from the seven primary laterals which remain. Instead of remaining feeble branches or dying, as is the habit of the tree, these laterals develop strongly and the crop is produced within easy reach of the collector (fig. 7).



FIGURE 6.—The plant shown in figure 5 after topping.

CORN

KERNEL TENDERNESS AND UNIFORMITY OF SWEET CORN

Three generations of selection from crosses between sweet corn and field corn were grown under irrigation. Marked improvement in kernel type was noted in one ear-to-row selection over those grown the previous year; over nine-tenths of the ears were uniform for large tender kernels. Tests made with a puncture-test machine on 68 ears indicate that all the hybrid sweet corns under trial compare well with northern varieties of sweet corn in tenderness of kernels.

Seed will not be available for general distribution until the sweet corn is also uniform for large plants and large ears; with this objective in mind crosses have been made between the more vigorous selections. As shown in figure 8, one of the hybrid sweet corns produced by the station averaged about 8 feet tall to the base of the tassel.

This compares well with native field corn and indicates that native sweet corn can be grown successfully if the right kind of seed is used.

SUPERIOR YIELDS OF SPRING-PLANTED FIELD CORN

Tests were conducted at the Isabela substation in cooperation with the College of Agriculture of the University of Puerto Rico comparing Isabela Common and Mayorbela corns with corn imported from Coamo and Yauco. Since the varieties differed little in yield, no advantage resulted from importing seed rather than using that



FIGURE 7.—Excelsa coffee plant 7 years from seed, and about 5 years after topping at the fourth pair of laterals, as described. As the land slopes steeply and the man is standing at a lower level, the effect of tree height is exaggerated.

grown locally. There were, however, marked differences in production between spring and fall plantings. Isabela Common planted April 1 averaged 54 bushels of shelled corn per acre, whereas the same variety planted August 21 averaged only 29.9 bushels. Figure 9 shows this graphically; beneath the bars, which represent average yields on one twenty-fifth acre plats replicated five times, are given the corresponding dates of planting. These results indicate that farmers in the Isabela district are probably correct in favoring the spring planting season.

ROOT CROPS

DASHEENS, TAROS, AND YAUTIAS

Fertilizer experiments were continued with dasheens, taros, and yautias, applying to the soil prior to planting varying amounts of manure and complete fertilizer. The station plain, however, in which these trials were made, had been flooded in March 1933 by the

river which had deposited large amounts of silt. Presumably owing to this, the crop yields failed to show a correlation with the fertilizer treatment.



FIGURE 8.—Illustrates the vigor of the sweet corn selected by the station and grown in the garden of George Anton. The plants averaged about 8 feet tall to tassel base.

YAM SELECTION WORK

The work in selection of potato yams, *Dioscorea esculenta*, according to high- or low-yielding strains, was seriously interrupted but not terminated by the submergence of the field by the flood of March 1933 in which most of the recently planted tubers were washed out and away by the river. Fortunately, a few remained in position and from these it was possible to preserve the strains and to make a

fairly extensive planting in the present season. This should give sufficient planting material to resume the work with the next crop at the point at which the flood interrupted. Most pronounced differences are here evident in the quantitative productive ability of the strains compared, and the importance of the work justifies its continuance.

EROSION AND TERRACING

Two years after setting with *Cordyline guineensis*, some terrace banks were fairly well protected against washing, whereas on others

the cover was still insufficient for the purpose. Guatemala grass covered the ground much more rapidly but for a permanent stand was considered less desirable for binding the soil on the banks of narrow terraces on account of its rank growth and the consequent shading of the terrace.

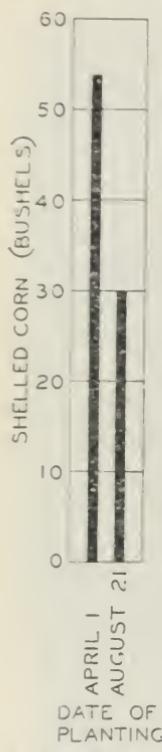


FIGURE 9.—
Spring-planted
field corn
at Isabela
outyielded
fall-planted
corn by 24
bushels per
acre.

PLANT INTRODUCTIONS

The one function which has perhaps contributed in larger degree than any other to the prosperity and beauty of the island since the establishment of the station has been the introduction of varieties of plants not previously grown in Puerto Rico.

Noteworthy and successful introductions of the present year were those of the green, yellow, and red varieties of the Malayan dwarf coconuts, the seed nuts, from which the young plants are now growing at the station, having been received from the Bureau of Plant Industry. These dwarf varieties offer decided promise for Puerto Rico since their early maturity, greater ease of collection, and presumably greater ability to withstand hurricanes are points of advantage over the taller-growing varieties. The smaller size of their nuts, however, is a disadvantage. Cuttings of 30 selected varieties of hibiscus received from G. L. Anderson, Fort Lauderdale, Fla., who has one of the largest and best hibiscus collections existent, were successfully established.

ANIMAL PARASITES

UNUSUAL ABUNDANCE OF PARASITES IN CATTLE

The precipitation for 1933 was above the average and the season of rains was longer than usual. Because of the greater moisture, there was an increase in the amount of infestation with internal parasites in cattle. This was most noticeable among pastured calves of the southwest part of the island, a region noted for its scanty rainfall. Ordinarily the injuries from parasites in young stock pastured on the well-drained slopes in this dry area are unimportant. But this year, even with the unusually luxuriant pastures, the mortality was high and the remaining animals

are in poor condition. Several stockmen lost their entire calf crop of the season. The greatest losses were from stunting and emaciation.

The parasites causing the damage as found on autopsy were lung-worms, stomach worms, *Haemonchus contortus*, and hookworms. The encysted stomach worm, *Ostertagia ostertagi*, was common. Specimens of nodular worms and whipworms were also found, but the infestations were mild and unimportant. Injuries and losses in other livestock also were reported, but no material was examined to determine the cause. The injuries caused by these worms in cattle are preventable. Published information and the personal advice and service of veterinarians are available.

DISTRIBUTION OF PARASITES

Apparently, the most injurious worms of cattle in the dry southern coastal plain are the common stomach worm, hookworm, and lungworm, while in the wet coastal plains the stomach worm, nodular worm, and liver fluke do the most damage. The lungworm and in some places the tapeworm also become serious pests in the wet areas if calves are placed on permanent pastures. As a rule, among these calves, where the hookworm is abundant the nodular worm is of little importance, and vice versa.

Calves, either in confinement or on pastures, can be maintained free of infestations of these worms if the proper sanitary methods are adopted or if the calves are moved to clean pastures often enough. In the absence of any or all of these control measures, treatment with anthelmintics should be given.

TREATMENT FOR PARASITES IN CALVES

The control of the cattle tick, although important, is only one of the parasitic problems confronting local cattlemen. Too many dairy-men have abandoned attempts to raise replacements for the herd because of diseases and parasites. To raise healthy calves, cleanliness of the feed, feeding utensils, and the pens is essential. The amount of feed must be carefully regulated the first few weeks according to size and age of calf. Calves often receive insufficient amounts of milk and concentrates during the first 12 months of age.

Calves may be exposed to infection with parasites the first few days of life. The source of infestation may be a contaminated pen or close contact with infested animals. Later infestations may be obtained from pastures, fresh forage grasses, or the drinking water.

An economical and satisfactory treatment for gastro-intestinal worms in calves is available. This is either the 1-percent solution of copper sulphate alone or combined with nicotine sulphate. Information in regard to preparation, dosage, and method of administration of this solution is available at the station. If calves from 2 to 9 or 12 months of age are fasted as recommended and are treated regularly every 2 or 3 weeks, a larger percentage will be raised and they will grow more rapidly on the same amount of feed.

SANITARY PENS FOR CALVES

In the wet coastal plain of Puerto Rico the common practice is to confine calves, in some cases until 18 months or more of age. The

tendency on many farms has been to crowd calves together in badly ventilated pens with poor drainage facilities. The proper construction of pens for these animals is important in preventing diseases and parasites. Usually poorly constructed pens cannot be kept in a sanitary condition even with considerable labor.

A modified type of pen (fig. 10) has been constructed for trial at this station. This pen was designed to utilize as far as possible the direct rays of the sun. In this climate the sun shines nearly every day throughout the year. The rays of the sun serve as an inexpensive drier and disinfectant and are very destructive to disease germs and the eggs and larvae of parasites.



FIGURE 10.—Sanitary calf pen of new design originated and erected at the Puerto Rico station.

The floor of the pen is made of concrete. The long sides facing north and south are open except for several pipes embedded in the concrete to support the roof and a piece of woven wire to act as a barrier. The roof is about one-half the height of the ordinary roof and covers one-half of the pen and is set on rollers. Each day the roof is moved over and left to cover the other half of the pen. This allows the sun to shine directly into the pen during the entire day. The roof provides sufficient shelter from the rain and also shade during the heat of the day.

As young growing animals require plenty of exercise and direct sunlight, a yard or corral adjacent to the pen is provided. The ground in this corral is sloped for drainage and is kept free of vegetation. The calves have access to this corral at all times. Both the pen and the yard are cleaned daily of manure and left-over feed.

Young calves kept in this pen and corral and fed on Guatemala grass supplemented occasionally with sugarcane during 8 months

are comparatively free of internal parasites. Occasionally an animal becomes infested with tapeworms, indicating that this worm is able to cross these control barriers, probably through the agency of an intermediate host.

THE PROBLEM OF PARASITE CONTROL

The daily and annual temperature ranges are comparatively small. There is, however, considerable variation in rainfall in different sections and at different seasons. The parasite problems of this and other tropical climates are principally affected by the amount and the character of the rainfall and the concentration of animals.

Although the island is small, the differences in amount of moisture and in other factors between the southern coastal plain and the other portions have resulted in differences in the management of livestock and have influenced somewhat the occurrence and character of parasites. On the southern coastal plain parasitic infestations of cattle and horses are largely a pasture problem. In the other sections, where young stock are confined, the problem is mainly contamination of forage grasses and lack of sanitation in stables and corrals. Owing to the limited amount of suitable and available land for cattle and its high value, most of the animals are concentrated on this limited and expensive land, with all the resultant dangers incidental to overstocking and concentration.

All of the terrestrial mammals except the bats are introduced species, and thus all the parasites have been and are continuing to be brought in from the outside. The earlier importations of livestock and domestic birds were from Europe, some importations were from India, and during the last 30 years importations have been largely from the continental United States. There have been from time to time importations of horses and cattle from nearby islands. At present the ratio of the new introductions to the so-called "native" stock is comparatively high.

As a rule, the worm parasites of animals and domestic birds are the same as those found in the United States. However, the arthropods, which are mostly external parasites, vary greatly from those found on the continent. There are several common and injurious parasites occurring in the United States that are not found here, principally arthropods unadapted to this climate or two-host worms for which a suitable intermediate host is probably lacking. Of these parasites it is known that some, and probably others, have been introduced a number of times, but they have been unable to maintain themselves. There are one or two common worm parasites found here that have not been reported on the continent of North America, but these are of minor importance.

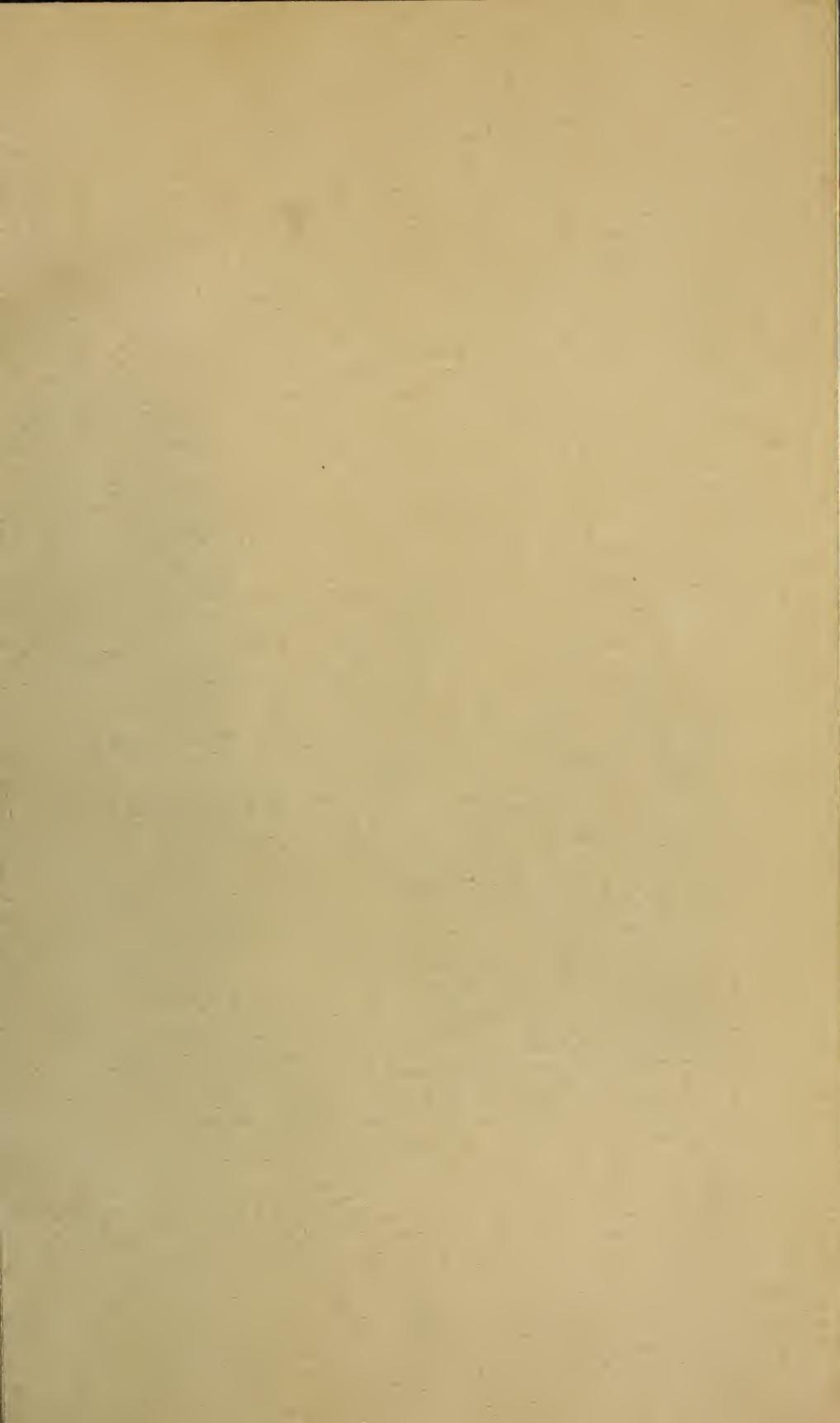
Some of the more noticeable variations of the arthropods as compared with those in the United States are as follows: Only one species of the horse bots, the throat botfly, *Gastrophilus nasalis*, has been found in native or acclimated horses, and infestations are mild; the ox warbles, *Hypoderma* spp., have been introduced many times, but have not become established; psoroptic mange is the common mange of the horse, while sarcoptic mange is rare; the cattle tick,

the tropical horse tick, and the brown dog tick are common, but these are the only ticks of any importance. Excluding the lice on dogs, cats, and birds, the only common lice on livestock are the tail louse, *Haematopinus tuberculatus*, on cattle, the biting louse, *Bovicola caprae*, and the African louse, *Linognathus africanus*, on goats; occasionally confined pigs become heavily infested with a sucking louse, *H. adventicius*. Of the diptera or flies, the stable fly, horn fly, large black horseflies, a deer fly, *Chrysops costata*, the black gnats, *Simulium* spp., and the screw-worm fly are found in Puerto Rico, but, with the exception of the horn fly, none of these are as abundant as the same or similar species in portions of the United States. Even the mosquitoes are less abundant than those in many localities in North America. The horn fly in the dry sections during 2 or 3 months of the year is probably as abundant as anywhere in the world. In addition to a less favorable environment for some of these arthropods, it is unnecessary to confine animals closely during a long cold season. Such confinement is more favorable for the increase of such parasites as mange mites and lice.

REQUISITES OF THE DAIRY INDUSTRY

Published data of the last census indicate that the average yearly production of the dairy cow in Puerto Rico during the year 1929 was approximately 1,600 pounds of milk. The amount of milk sold per capita was 5.3 gallons. While both figures are low, they show a considerable increase over the averages of 1,300 pounds and 2.5 gallons, respectively, of the 1920 census.

The increasing per capita consumption of milk products and the growing population are resulting in a greater demand for milk and milk products. There is a large undeveloped market for fresh whole milk. Because of the comparatively high cost of producing milk, this demand should be met not by more dairy cows but by an increased production per cow. One of the greatest hindrances to increased production is the presence of the cattle tick. It is said that the shrinkage in milk production of cattle harboring many ticks will average 1 quart a day. Incidentally, ticks interfere with practically all the experimental work performed with cattle. With new and additional funds available for research in animal husbandry, it is essential that the ticks should first be eradicated. With the eradication of the tick, livestock owners will be able to raise cattle under more favorable conditions. Further improvement can be obtained by introducing more high-producing animals, especially carefully selected purebred bulls. A great need even at present is the adoption of a program of group purchase. If all the livestock imported each year from continental United States could be selected by experienced livestock men and combined in one shipment, there would be a considerable saving in freight, and the importer would obtain better stock at a lower average price than under the present unorganized and expensive system of purchase.



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